Global ecosystems in a post-fossil world

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Abstract

In the last few decades oil has been consumed at a much faster pace than new reserves have been discovered. We are approaching the point where about the half of the ultimately recoverable reserves has been consumed up. When this point is reached, global oil production will attain a peak ("peak oil") and arrive in a period of unavoidable decline. This will definitely result in considerable ecological impacts, changing both conscious (land use) and external (pollution) environmental impacts of human activities. Peak oil will challenge modern western conservationism, promoting a shift from a global towards a local perspective, and from conservation towards sustainability in the focus. Given the vital importance of ecosystems and ecosystem services in a post-oil era, it is crucially important how we manage to lead through our ecosystems during the transition period. Integrated impact assessments are urgently needed to facilitate a smooth transition into a post-peak-oil era, without disrupting world's still plentiful biotic resources during the transition.

Introduction

Ecologists have been long warning society that the concept of continual growth on a finite planet is flawed and may result in some form of a decline driven by natural constraints sooner or later (MEADOWS et al. 1972, EHRENFELD, 2005). Current trends of industrialization and globalization raise a series of issues (i.a. climate change, ozone depletion, erosion of biodiversity), which have the potential to exert detrimental impact on our civilization in the near future. A less recognized, but potentially imminent threat for the status quo of our society is known as 'peak oil', which is set to bring the age of cheap oil to an end in the near future (CAMPBELL and LAHERRERE, 1998). This term refers to the point when global oil production reaches a peak followed by inevitable decline, approximately when half of the oil reserves have been used up. This event would mean for global economies that extensive growth in terms of oil consumption is no longer possible, and supply constraints will drive up prices even for unchanged demand. The resulting imbalance in oil production and demand can be seen as the first hard symptom of reaching the limits for our growth-centred society, which will have tremendous consequences for modern Western civilization. Since at present the functioning of our society is based on the cheap availability of fossil fuels, the forthcoming oil shortage will pose a great challenge for all human activities, with potentially dramatic influence on ecosystems and nature conservation.

Peak oil

According to geological considerations, the production of an oil field follows a bell shape curve, where the production starts to decline well before all resources are depleted. The first oil fields drilled contained good quality oil under high pressure relatively close to the surface. During the last 150 years the "low hanging fruits" of the most easily accessible oil sources have been used up, and despite enormous efforts, new discoveries are in steady decline since

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the early 1960s (CAMPBELL and LAHERRERE 1998, Fig 1). In 1956 analyzing the trends in new discoveries and the production curves of individual oil fields Shell geologist M. King Hubbert formulated a model to predict the timing of the peak production of larger areas. With his model Hubbert successfully predicted the peaking of oil production in the conterminous US by 1970 (HUBBERT, 1956). Since then a wide series of oil producing nations, including all industrialized countries, have reportedly reached their peak production (WWI, 2005), indicating that global oil production might not be far from peaking either.

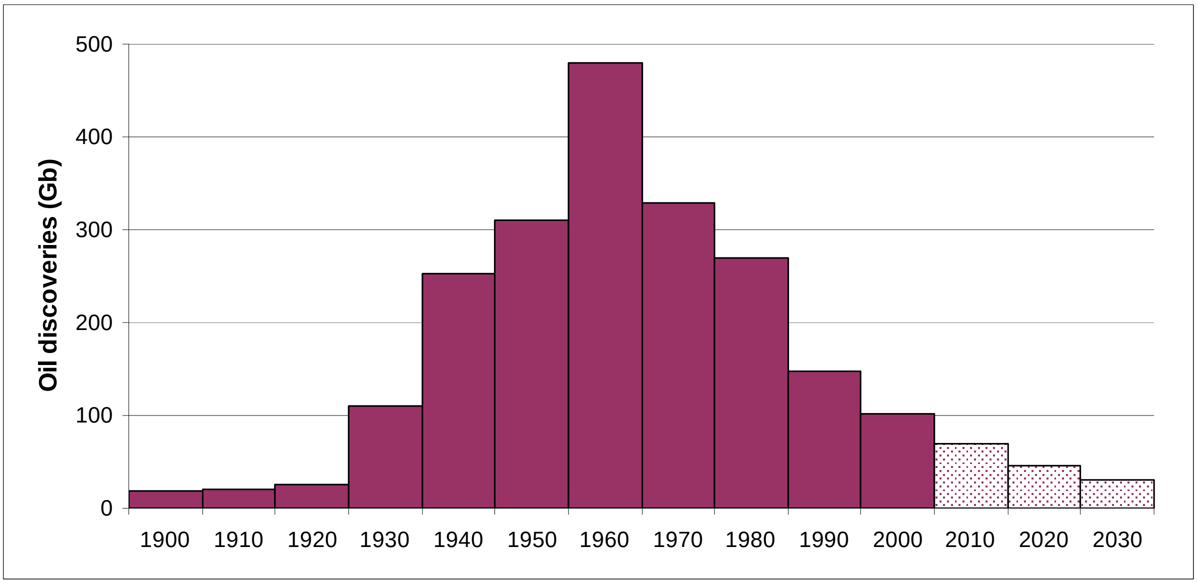

Figure 1. *Historical oil discoveries and an extrapolation for the future (Source: ASPO)*

Abundance, high energy concentration, and the ease of extraction, storage and transportation have made petroleum a fuel of choice for present-day human societies. There are no easy alternatives for oil (HIRSCH et al. 2005). Apparently, natural gas could be a salient substitute, but unfortunately it also faces a similar peak-and-decline future (ALEKLETT and CAMPBELL, 2003). Other fossil alternatives, such as tar sands, oil shales and extra heavy oils (sometimes termed as "non-conventional" oils) and coal all have some significant drawbacks, being both technically (no mature technology to produce effective substitutes in adequate quantity) and environmentally (demand large-scale strip mining and energy-intensive pre-processing) unfeasible (SALAMEH, 2003). Nuclear power and renewables are also limited as a substitute, since they are unlikely to be able to meet the energy needs of modern western societies in the foreseeable future due to scaling problems (SALAMEH, 2003, EWG 2006). Declining availability of oil constrains use of the entire human energy infrastructure because petroleum products are used to extract, deliver, and process all fuels and raw materials (and to manufacture "alternative" energy technologies) (HIRSCH et al. 2005).

The consequences of shortfalls in oil production can be illustrated by the aftermath of the US oil peak in 1970, creating the conditions for the energy crises of the '70s, where ~5% of decline in production resulted in nearly quadrupling prices and a 3% drop in the US GDP (HIRSCH, 2008). However, at that time it was possible to return to business as usual based on foreign oil – an option that will not be available in the present case. World's oil dependency has only increased since then. For example, for every one joule of food consumed in the United States, around 10 joules of fossil energy have been used to produce it (PFEIFFER, 2006). Hydrocarbons are feedstock for plastics, pharmaceuticals, fertilizers, electronic components, but most importantly oil is the most convenient and versatile fossil fuel, currently accounting for about 43% of the world's total fuel consumption and 95% of global energy used for transportation (IEA, 2007).

Peak oil, similarly to climate change, constitutes a typical post-normal problem (FUNTOWICZ and RAVETZ, 1993), where facts are uncertain, values are diverse and stakes are high. No wonder that the both the timing and the potential consequences of peak oil are still under intensive debate among scientific, industrial and governmental communities. While governmental agencies and multinational oil companies tend to draw an optimistic picture on future oil availability, other more critical calculations place global production peak in the very near future, or even in the recent past (BENTLEY and BOYLE, 2008). In fact, oil production has not increased significantly since 2005 despite the heavy increase in fuel prices and the habitual pledges of the major producers to increase production. The current economic crisis and the increased price volatility of oil may actually be regarded as symptoms of having approached or reached peak oil (HAMILTON 2009). Accordingly, we may have arrived or will arrive soon at a major turning point of human history with several severe social, economic and environmental implications, which demand careful consideration and proactive preparation (HIRSCH et al. 2005).

Facets of peak oil for biodiversity

Limited availability of fossil fuels will impose a huge impact on humanity, no matter when the actual peak arrives. As human activities are by far the most important drivers of global ecological changes, social regime shifts will definitely induce ecological changes. On the other hand, these changes can impose detrimental feedback on the human society, gradually deprived of its energetic self-sufficiency based on the continuous flux of appropriated fossil fuels.

But what kind of impacts peak oil will have on ecosystems and ecosystem services? Naively one could assume that fuel scarcity and the accompanying breakdown of energy intensive solutions could bring instant relief on nature, but the reality will definitely be more detailed, partly depending on the policy choices to be formulated in face of the challenges. Raising energy concerns, for example, might defeat environmental considerations; resulting in environmentally detrimental solutions on any scales from local to global, e.g. oil production from tar sands already in process demands vast strip mines, large amounts of water, and produces large quantities of different wastes and CO_2 due to its relatively poor energy efficiency. Other potential policy responses, such as extended biofuel plantations hold the same controversies. Cutting down on fuel usage will definitely bring significant changes to the current energy-intensive forest management and agricultural practice. The pattern of change, however, will deeply depend on the local socio-economical driving forces and can result in either abandonment or over-exploitation. As a general trend, human activity will be more localized, which can also have serious implications on ecosystems. In Table 1 we summarize the most evident mechanisms, by which fuel scarcity and the resulting social transitions may affect biodiversity.

	Advantages	Disadvantages
Agriculture	decrease in cultivation intensity	potential increase in agricultural (+biofuel) area
Forests	return to traditional forest management schemes	potential overexploitation of forests for firewood
Tourism and transportation	decrease in pressure of new alien introductions due to limited mobility and commerce, landscape diversity should increase since all basic human needs should be met more locally	decrease in tourism revenues, including ecotourism
Climate policy	decrease in CO_2 emissions (from oil and natural gas)	potential increase in CO_2 emissions (non-conventional oil and coal)
Conservation policy	increasing focus on local sustainability	declining interest in large scale issues, weakening of international programs and institutions

Table 1. *The most important impacts of peak oil on ecosystems grouped by sectors* (CZÚCZ et al. 2010)

From the perspective of the human perception of ecosystems and their services a further layer of thought can be added. Modern western society found ways to increase the supply of provisioning services (or ecosystem goods, such as food or fibre production) at the expense of other services (such as pollination, water regulation or aesthetic beauty) – by means of intensive management techniques powered by fossil energy (MEA, 2005). The problem is deeply rooted in the fundamentals of market economy, which absorbed ecosystem goods relatively easily, whereas all other, non-provisioning services were barred outside as commons. Observing the decline in these commons, their protection became the main focus of modern conservationism. The descent towards a low-carbon society will presumably change this situation. Modern, coordinated, large-scale conservation activities are likely to give way to a local, sustainability-centred attitude, which currently can be detected in poor countries (ROE and ELLIOTT, 2005).

Conclusions

The descent towards a low-carbon society will probably be accompanied by economic turmoil and a high level of social tensions, which will definitely cause major impact on ecosystems as well. It is important to enumerate these potential impacts and assess the uncertainties, so that when things happen to arrive, society would not be taken by surprise. Surprise and panic can initiate the worst solutions. Even though the potential challenges caused by peak oil are of a similar magnitude to those caused by climate change, there has been very little scientific and policy attention devoted to this complex issue. Similarly to climate change, integrated impact, adaptation and vulnerability assessments are urgently needed to facilitate a smooth transition into a post-peak-oil era, without disrupting world's still plentiful biotic resources during the transition.

References

ALEKLETT K., CAMPBELL C. J. 2003. The peak and decline of world oil and gas production. *Minerals and Energy – Raw Materials Report*, 18(1): 5-20.

BENTLEY R., BOYLE G. 2008: Global oil production: forecasts and methodologies. *Environment and Planning B: Planning and Design* 35: 609–626.
CAMPBELL C. J., LAHERRERE J. H. 1998: The end of cheap oil. *Scientific American* 278: 60-65.
CZÚCZ B., GATHMAN J. P., MCPHERSON G. R. 2010: The impending peak and decline of petroleum production: an underestimated challenge for conservation of ecological integrity. *Conservation Biology* 24: 948-956.
EHRENFELD D. 2005: The environmental limits to globalization. *Conservation Biology* 19: 318-326.
EWG (Energy Watch Group) 2006: Uranium resources and nuclear energy. EWG-Series No. 1/2006. EWG, Berlin, 48 pp.
FUNTOWICZ S. O., RAVETZ J. R. 1993: Science for the post-normal age. *Futures* 25: 739-755.
HAMILTON J. D. 2009: Causes and consequences of the oil shock of 2007–08. *Brookings Papers on Economic Activity*, Spring 2009: 215–261.
HIRSCH R. L. 2008: Mitigation of maximum world oil production: Shortage scenarios. *Energy Policy* 36: 881-889.
HIRSCH R. L., BEZDEK R., WENDLING R. 2005: Peaking of world oil production: impacts, mitigation and risk management. Report to U.S. Dept. of Energy – Natl. Energy Technol. Lab. Science Applications International Corporation, San Diego, CA, 91 pp.
HUBBERT M. K. 1956: *Nuclear Energy and the Fossil Fuels*. Publication No. 95. Shell Development Company, Exploration and Production Research Division, Houston, TX. 57 pp.
IEA (International Energy Agency) 2007: *Key world energy statistics 2007.* IEA, Paris, 82 pp.
MEA (Millennium Ecosystem Assessment) 2005: *Ecosystems and Human Well-Being: Synthesis*, Island Press, Washington, DC, 160 pp.
MEADOWS D. H., MEADOWS D. L., RANDERS J., BEHRENS W. W. 1972: *The Limits to Growth* Potomac Associates, Washington, DC, 205 pp.
PFEIFFER D. A. 2006: *Eating Fossil Fuels: Oil, Food and the Coming Crisis in Agriculture*. New Society Publishers, Gabriola Island, BC, 144 pp.
ROE D., ELLIOTT J. 2005: *Poverty-conservation linkages: A conceptual framework*. Poverty and Conservation Learning Group, International Institute for Environment and Development, London, UK. 12 pp.
SALAMEH M. G. 2003: Can renewable and unconventional energy sources bridge the global energy gap in the 21st century? *Applied Energy* 75: 33-42.
WWI (World Watch Institute) 2005: *State of the World 2005: Redefining Global Security*. Norton, NY, 107 pp.